US Senate Committee on Commerce, Science and Transportation
Hearings on Election Reform

Prepared Testimony
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Thank you for inviting me to speak today.

I'd like to begin by telling you a little bit about our project, and then tell you about some specific findings.

Overview of the Caltech/MIT Voting Technology Project.

A week after the 2000 presidential election, David Baltimore, the president of Caltech, called Charles Vest, the president of MIT, with an idea. Our two institutions should collaborate to develop improved voting technologies – a new voting machine. They believed that the problems observed in the vote counting in Florida and elsewhere originated with technology.

Presidents Vest and Baltimore assembled a team of computer scientists, mechanical engineers, and social scientists. The Carnegie Corporation and both Caltech and MIT have funded our endeavors.

I'm Steve Ansolabehere, a professor of Political Science at MIT, and co-director of the Caltech/MIT voting technology project. My counterpart at Caltech is Tom Palfrey, a professor of Economics. Our team consists of 11 faculty and many students, and our central goal is to develop new voting technology. The engineers bring expertise in electronic security, user interface design, machine design, and performance standards. The social scientists bring expertise in voter behavior, operations design, and public finance.

We are in the initial phase of our project, which I consider the learning phase. Over the last four months we have met with many voting machine manufacturers and election administrators to ascertain what the problems are and to explore ways that we can contribute to solutions. We have also conducted studies of voting machine performance and design, the public finances of election administration, and voter registration practices. A complete report of our work over the last four months is due out at the beginning of July. It will include our assessment of existing voting processes in the United States. The report will also offer specific recommendations for the industry, governments, and universities to pursue.

The second phase of our project will focus on equipment design. We've identified a number of user interface and security features of existing equipment that can be improved upon. We have identified specific practices in voter registration and polling place administration that can be improved at minimal cost or with cost savings with the use of computer technology. We have also identified the need for a process that would involve industry, government, and universities in continual innovation in voting equipment and software.

Where Technology Affects the Voting System

Like most Americans, I have always taken the voting system for granted, even though I have voted with every kind of technology. With a little introspection, it is evident that computing technology has driven changes in voting technology. Today, we are in the midst of a computing and communication revolution, and that revolution will change the voting system over the next decade.

The question before us is how can we make the transition to new voting systems a good one.

There are three big pieces to the voting system where our group see technology, and, in particular, computer technology, changing the picture. These parts of the system are voter registration, casting of votes, and counting of votes.

First, Voter Registration. The registration system serves two purposes: *authentication and management*. It is used to authenticate the voter. That is, to make sure that those who are not allowed to vote do not and that those who are allowed to vote do so only once. Registration is also used to manage the ballots. We vote on so many different offices and questions today that it has become a chore simply to keep straight who should vote on what. Voter registration information tells people what polling place to go to and it allows the administrators to distribute the ballots to the right polling places.

Voter registration poses considerable database management problems for counties. How to keep the files up to date and free from incorrect or duplicate registrations? How to access the voter registration rolls at polling places on election day? Computing advances now afford improved database management. As the cost of maintaining and accessing databases has fallen, many counties and states have begun to computerize voter registration information. Excellent examples are the states of Kentucky, Maryland, and Michigan. Some counties have even linked the polling places to the counties' central voter files, substantially reducing polling place problems created by inaccurate registrations or by people going to the wrong polling place. A good example is Orange County, Florida.

Second, Casting Votes. The act of casting a vote is fundamentally *communication*. Voters need a way to communicate their preferences and intentions: dropping a chit in a dish, raising their hands or voices, marking a piece of paper, pulling a lever, or, now, touching a screen.

Since 1990, there have been important developments in understanding how to make computers more user friendly to the everyday person. Improvements in user interface design – the look and feel of electronic ballots – will improve the acceptance and usefulness of electronic voting machines. The challenge is how to implement better ballot designs.

Third, Counting Votes. With the close of polls begins an enormous *computing or tabulation* problem. A brief history of the technology reveals the importance of computational speed.

- Hand counted paper ballots are slow.
- Lever machines speed up the count by aggregating many ballots at the precinct, leaving the administrator to tally the counts on the backs of the three or four machines at the polling place.
- Punch cards improved on this by providing and fast counts of all ballots at once.
- PC connected punch cards, scanners, and DREs permit the counts to be sent in via modem – faster still.

With speed has probably come greater confidence in the process and less opportunity to tamper with ballots. Additional gains in the speed of counting are marginal at best. But there is a need for improved security and auditability of counts. With electronic counting we sacrifice the observability or visibility of the count. In most states this is done publicly, with representatives from the parties to check the counting. That check has been lost, and that check often caught problems. One challenge is to devise a new systems of automatic checks that would highlight suspicious looking counts. Also we feel that standards for auditability need to be developed.

The Current Voting System

Before our group set out to consider equipment design, we first tried to answer two questions. First, how much is currently being spent on voting equipment, specifically, and election administration, generally? Second, how accurate is the equipment being used today? Is there any opportunity for substantial improvement?

Election Expenditures and Equipment Costs

1. How much does equipment cost?

We see that two technologies are competing for the immediate future of voting: optical scanning and electronic machines, called direct recording electronic machines, or DREs for short. According to estimates provided by industry to us and based on recent acquisitions that we have studied, the cost of acquiring a DRE is approximately $18 to $25 per voter. The operating or variable cost for electronics is about $.50 to $1 a voter. The cost of acquiring a scanner system ranges from $3 to $8 per voter. The operating cost for scanners ranges from $1 to $2 a voter.

A nation-wide upgrade today would be expensive. If we were to upgrade completely to electronics, assuming prices remained the same, the acquisition cost would be approximately $2 billion ($20/voter and approximately 100 million voters). If the US were to adopt scanners, the cost would be approximately $600 million ($6/voter and approximately 100 million voters).

2. How big is the voting equipment industry?

Industry executives estimate that total voting equipment sales range from $150 million to $200 million per year.

The industry consists of four main firms and approximately 20 smaller firms, as well as many local contractors. Election Software and Services (ES&S) is the largest firm, followed by Guardian (a division of Danaher), Global, and Sequoia Pacific. Guardian vends the most widely used electronic machine, the 1242, which used to be called the Shouptronic. ES&S, Global, and Sequoia offer many different machines, including DREs and scanners, and offer some services, such as ballot design, printing and data base management.

Large firms stay out, but when they enter they bring significant design innovations. IBM and Unisys are cases in point. IBM was one of the first punch card innovators, but they got out of the business in 1968 because of bad publicity. IBM spun off two companies, CES and EVM, which became two of the main punch card vendors. In the mid-1980s, Unisys developed the Optech scanner, the most widely used scanner in the US, but withdrew from the industry.

Industry executives estimate that total voting equipment sales range from $150 million to $200 million per year. This appears to be consistent with data that we have collected on total number of changes in equipment per year.

An upgrade to new equipment, then, would be three to 15 times more than the size of the industry today. That seems quite expensive. But it is the wrong calculation; one must also include the time horizon.

Electronic equipment will probably last 15 years, before it becomes badly obsolete. Over a 15 year span (approximate life of these machines), we would spend nationwide between $2.25 billion and $3 billion on machines anyway. That is, if revenues are between $150 annually and $200 million annually, then over 15 years we expect to spend 15 times the revenues. At today's machine prices a complete upgrade to DREs would be approximately $2.5 billion, which is in the range of what the counties and municipalities would spend anyway.

One concern is the effect of a massive upgrade. The industry may not have the capacity to fill orders. Such a large infusion of cash might increase prices. And, an immediate and complete upgrade would kill demand for the next 5 years or so, which might kill the industry.

A second concern with an immediate upgrade concerns the public financing. Because equipment is mainly sold rather than leased, county budgets would have to absorb sizable capital costs. A separate capital request is required, which is often more difficult than a request for additional operating funds. Leasing is a solution that would smooth the costs over the life of the machine.

A more general matter is how much do we spend on elections overall. When we began this project, it became immediately apparent that such a figure does not exist. We found audits of several counties and projections based on those counties, but we found no estimates of nation-wide expenditures. If anyone knows of studies of election administration spending nation wide, we'd appreciate any information you have.

To fill this void, we surveyed county administrators throughout the country by sending them faxes to ask how much they budget for election administration. This gives us a ball park estimate of the nation-wide expenditure on all aspects of elections. The data are still coming in, but I can share with you our preliminary findings. In the 2000 elections, the US counties and municipalities spent (on average) approximately $8.80 per voter on all election administration. That works out to approximately $1 billion nation wide.

This figure includes all expenditures -- voter registration, salaries, office overhead, equipment purchases, equipment maintenance and storage, poll worker training and pay. Ernest Hawkins, the Sacramento County registrar, has performed an excellent cost analysis based on that county's expenditures. His total figure is slightly higher, but not much.

The $1 billion figure suggests that there are considerable financial constraints on immediate upgrading to equipment. County election boards must make capital budget requests. One possible solution is leasing, which Rhode Island has done. This moves the line item for equipment acquisition out of the capital budget and into the operating budget, which is more affordable.

Performance of Current Voting Equipment

A second study we have undertaken concerns the accuracy of existing equipment. This study is posted on our web page (www.vote.caltech.edu) and we have provided copies to the Committee.

We undertook this study to establish some benchmarks:

- How many votes are unmarked, spoiled, or uncounted, and thus problematic in the event of a recount?

- Does the incidence of such ballots depend on the equipment used?

The incidence of unmarked, spoiled, and uncounted ballots (which we call residual votes) is particularly important because it is a measure of the number of questionable ballots that must be resolved in the event of a recount. It does not, however, measure all mistakes that voters may make in the voting booth or all problems with equipment in registering voters' preferences and it does capture some intentional non-voting.

If the incidence of residual votes is unrelated to machines then it may be unlikely that design improvements could help. However, if the incidence of residual votes does depend on equipment, then it is important to know which technologies are doing particularly well.

We collected data on election results and equipment used in each of the counties in the US for the 1988 to 2000 election. We began data from Election Data Services data and proceeded to fill in data for states not covered in that data base. We also augmented that data with data from 2000, and we carefully checked the data for errors.

There are some odd observations in the data (very few) that we were unable to resolve. We have omitted these cases.

The metric we use is the percent of total ballots cast for which no presidential vote was registered. This does not capture all errors, but it does capture those votes that would be problematic in the event of a recount or an audit of the election.

The average county in the United States has a residual vote rate in presidential contests of 2.3 percent. The percent of all ballots cast that had no presidential vote recorded equals 2.1

percent. The figures differ because larger counties have lower residual vote rates. We suspect that this is because they have more resources to administer elections.

We then performed several statistical analyses to assess the extent to which the residual vote rate depends on what voting equipment in use. It does. And some of the results surprised us.

First, we looked at simple averages. For each type of voting equipment, what is the average residual vote rate?

Counties using punch cards, either Votomatic or DataVote, had the highest residual vote rates – 3 percent of total ballots cast.

Counties using direct recording electronic equipment also averaged residual vote rates above the national mean.

The average residual vote rate among counties using optical scanning, lever machines, or hand counted paper ballots were below the national mean.

Results that we will include in subsequent versions of the report look at elections fo US Senate offices. Here again, optical scanning and hand counted paper are well below the national average. Punch cards are again above the mean. And DREs are double the residual vote rate of counties with scanning or paper. Lever machines also have higher than average residual vote rates for US Senate races.

Many factors may affect the residual vote rate. So we tried to control for these other factors statistically. Doing so did not change the results.

Holding constant county-level factors, such as racial composition, literacy rates, income, and age, we find the same pattern. Hand counted paper ballots, optically scanned ballots are significantly better than Direct Recording Electronic equipment and punch cards.

This is not to say that those other factors do not matter. A County's average per capita annual income, racial composition, percentage of voters over age 65, voter participation rates, and other factors, strongly affect the incidence of residual votes. Rather, holding those factors constant we still find the same pattern of effects:

Hand counted paper ballots and optically scanned paper ballots and lever machines on average had significantly fewer unmarked, uncounted, and spoiled ballots than punch cards and electronic machines.

Our immediate reactions to these results were two-fold.

First, there is a good case to be made against punch cards. They are an established technology, and they are, on average, performing poorly.

Second, these results sparked a heated debate within our group between adherents of paper (optically scanned or hand counted) and adherents of electronics. We have subsequently studied much of the equipment on the market, and we feel that design improvements for DREs are possible. This is the challenge facing our engineers. The results clearly set paper – hand counted or optically scanned – as the benchmark, the thing to beat.

Doing so will require less attention to designs that speed up the count and more attention to designs that are easy-to-use, that start with the many different types of voters in mind.